UNIVERSITY OF
ILLINOIS LIBRARY
AT URBANA-CHAMPAIGN
STACKS

Digitized by the Internet Archive
in 2011 with funding from
University of Illinois Urbana-Champaign

http://www.archive.org/details/modalchoiceworkt623colw

13. Sheth, J. N. and P. L. Wright (eds.) (1974), Marketing Analysis for Societal Problems, Bureau of Economic and Business Research, University of Illinois.

14. Zaltman, Gerald (1974), "Strategies for Diffusing Innovations," in Sheth and Wright (eds.) Marketing Analysis for Societal Problems, Bureau of Economic and Business Research, University of Illinois.

Faculty Working Papers

MODAL CHOICE AND WORK TRIPS

Peter F. Colwell, Associate Professor,
Department of Finance
Bruce S. Vanderporten, Loyola University

#623

College of Commerce and Business Administration
University of Illinois at Urbana-Champaign

FACULTY WORKING PAPERS

College of Commerce and Business Administration

University of Illinois at Urbana-Champaign

October 24, 1979

MODAL CHOICE AND WORK TRIPS

Peter F. Colwell, Associate Professor,
Department of Finance
Bruce S. Vanderporten, Loyola University

#623

Summary:

Theoretically, the choice of mode for the work trip is determined by the abstract characteristics of the modes, the technology with which modes are combined, labor market opportunities, and preferences. Institutional constraints on labor markets have important effects. For example, the commuter who must conform to a standard work day or who receives higher way rates from working full-time than part-time may optimally choose to mix modes over time. However, the attractiveness of modal mixing is diminished when economies of scale exist in taking certain modes. With flexible hours at a part-time wage rate and inflexible hours at a higher full-time wage rate, upper and lower bounds can be established for valuing a transport improvement. Finally, the theory of modal choice suggests structural characteristics for empirical models.

MODAL CHOICE AND WORK TRIPS

Bruce S. Vanderporten and Peter F. Colwell*

Introduction

As new modes of transportation are introduced and existing modes are modified or discontinued, the total number of trips taken as well as the distribution of trips among modes changes. Further effects on travel choice arise from changes in individual preferences and labor market opportunities. These changes in travel decisions have interesting welfare implications.

Three landmark articles in urban transportation economics have examined these issues or closely related issues from different perspectives. These are Moses and Williamson [4], Quandt and Baumol [5], and Gronau [2]. The purpose of this paper is to provide a common framework for examining these seemingly disparate transport studies. The often implicit assumptions of these studies will be identified in relation to how they influence modal choice and how relaxation of these assumptions may lead to other choices. The paper will also focus on the subsidy issue in urban transport and attempt to establish more narrow limits in valuing transport improvements. Finally, the paper will attempt to explain how the theory of modal choice can be useful in specifying empirical transport demand models.

It is advantageous to define modes by their abstract characteristics. That is, rather than identifying actual modes, transit forms are defined

---

*The authors are Assistant Professor of Economics at Loyola University of Chicago and Associate Professor of Finance at the University of Illinois - Urbana, respectively.

by characteristics such as cost, travel time, comfort, frequency of service, etc. Thus, theoretical and empirical predictions of demand for nonexistent, but conceivable modes are possible. Cost and travel time are the characteristics given primary emphasis in all three articles. This study will follow the emphasis of these articles and focus on these two characteristics.

The Gronau Model

The simplest and least general of the articles is by Gronau. He considered alternative modes of travel by their cost (C) and time (T) characteristics. With two modes, A and B, where $C_A > C_B$, both modes will be relevant if $T_A < T_B$. If $T_A > T_B$, mode A is an irrelevant mode, since with its higher cost and time characteristics, it would never be rationally preferred to mode B.

Of the two relevant modes shown in Figure 1, mode A is the faster and costlier while mode B is the slower and cheaper. The marginal cost of time (MC) is the additional cost the traveler incurs per unit of time when taking mode A rather than mode B.

$$MC_{AB} = (C_A - C_B)/(T_B - T_A).$$

In Figure 1, MC_{AB} is the negative slope of line sement AB. In Gronau's analysis, a traveler's choice of mode depends on the relation between his unit value of time (V) and the marginal cost of time. This may be represented by considering two isoexpenditure lines, E_1 and E_2, where the negative slope of each equals the traveler's unit value of time. Since lower isoexpenditure lines indicate smaller expenditures, a

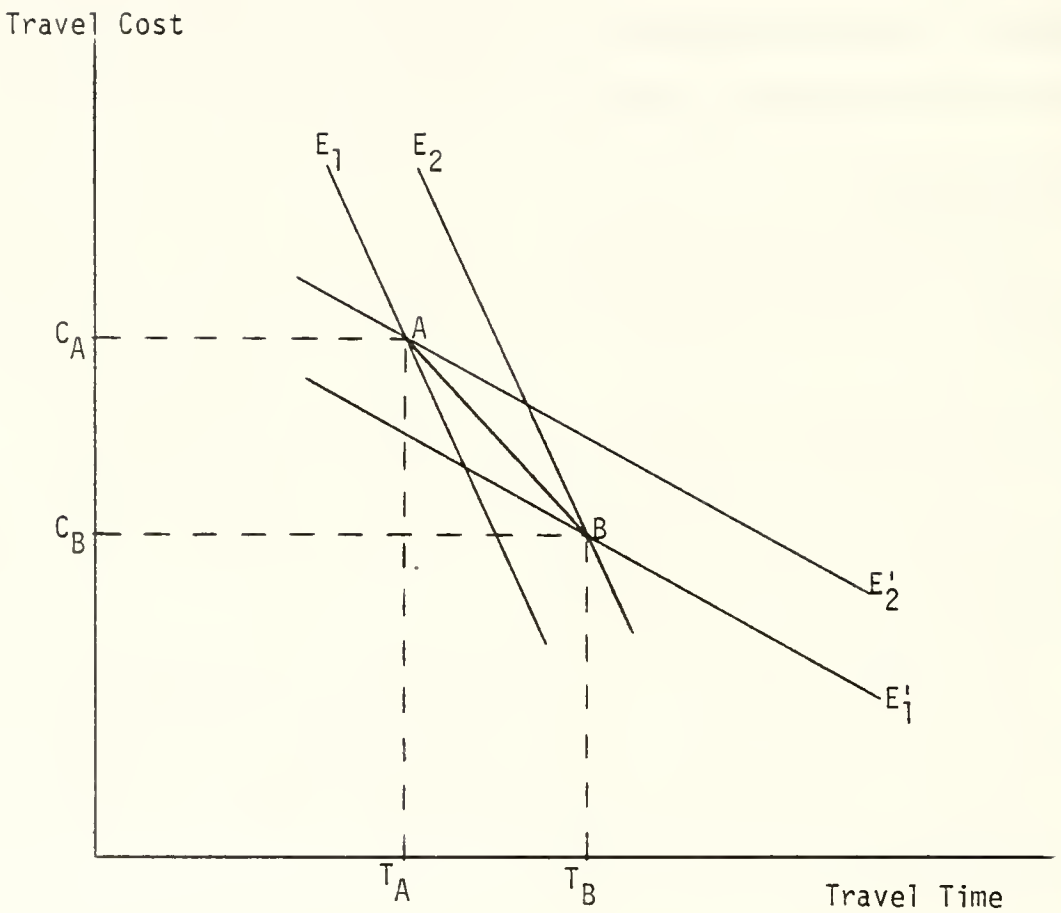

Figure 1

traveler prefers that mode which places him on the isoexpenditure line closest to the origin. With isoexpenditure lines E_1 and E_2, the mode of choice would be the faster and costlier mode, A. Here the traveler's unit value of time exceeds the marginal cost of time in taking mode A ($V > MC_{AB}$). For the traveler who places less value on his time such that $V < MC_{AB}$', mode B would be the preferred choice. This case corresponds to isoexpenditure lines E_1' and E_2' in Figure 1.

While Gronau's analysis provides some insight into modal choice, its restrictive assumptions seriously limit the range of that choice. In particular, Gronau assumes a constant unit value of time which is presumably related to preferences and opportunities but is not made explicit. The difficulty with this assumption is that it rules out the existence of certain modes and combinations of modes which would not be ruled out in the framework of conventional consumer choice theory. A further unfortunate result of the Gronau approach is that a point other than a modal point may never be though of as uniquely optimal.

One way in which the Gronau model restricts travel choice can be seen by considering a new mode D such that $C_A > C_D > C_B$ and $T_A < T_D < T_B$. Since D is not dominated by A or B in all of its characteristics, it is not an irrelevant mode. Yet D can never be chosen if $MC_{AD} < MC_{DB}$. Figure 2 illustrates this situation. It is impossible to construct an isoexpenditure line through D such that a lower isoexpenditure line could not be attained by selecting either mode A or B.[1] This implies that for a new mode such as F to exist alongside A and B, mode F would need to possess characteristics which would cause AFB to be convex to the origin.[2]

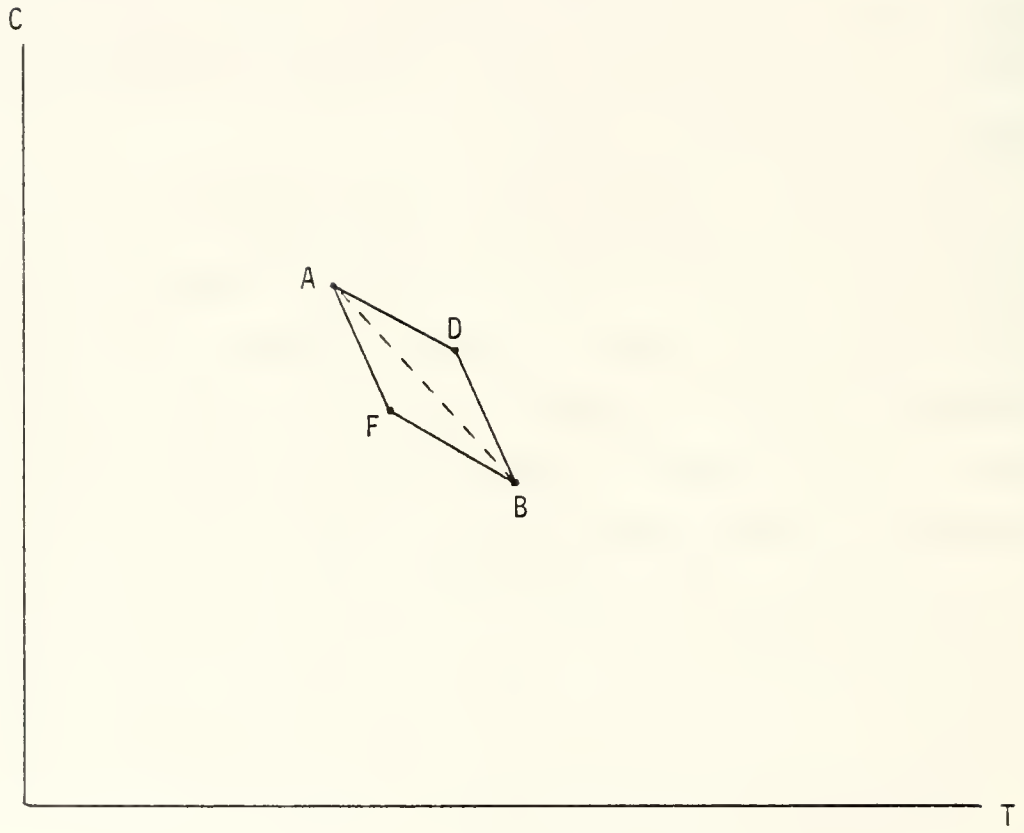

Figure 2

The usefulness of the line AFB to the Gronau analysis is that it suggests that any modes to the northeast of it would never be chosen. While Gronau refers to lines connecting relevant modes such as AFB as isoquants, the terminology is somewhat unusual, since such lines do not represent the actual opportunities available to a traveler. Rather, the line AFB just connects opportunity points, A, F, and B in Figure 2. For this line to represent an isoquant would require some knowledge about how the modes, A, F, and B may be combined.

A Modification

The first modification of the Gronau model will be to allow for mixing of modes. That is, rather than restricting the choices confronting a traveler to discrete modes A or B in Figure 1, a traveler is able to choose linear combinations of the two modes. For example, if the modal choice is between an automobile with monetary outlay of $2.00 and travel time of 30 minutes and a bus with a fare of $.50 and travel time of 60 minutes, the traveler might select two auto trips for each bus trip to give an average trip cost of $1.50 and travel time of 40 minutes.

The actual use of linear combinations assumes certain conditions are present.[3] In particular, for straight line AB in Figure 1 to represent the opportunities open to a traveler requires that constant returns to scale be available in both modes A and B and that no indivisibilities be present. When just one trip is involved, the assumption is hardly realistic. That is, if the journey from Baltimore to Houston is arranged so that half the trip is made by airplane and half by bus, it is not likely that the cost-time expenditure would fall midway between

the cost-time expenditures from exclusive use of either mode. But where there is a round trip in which one leg is by airplane and the other by bus, the combined cost-time expenditure would fall close to equally between the cost-time expenditures derived from using either mode alone. The presence of indivisibilities rules out the existence of all but one opportunity between A and B for one round trip. As the number of trips increases, the opportunity expands for linear combinations along AB. If both the automobile and bus are relevant modes for the work trip, four combinations involving some use of each mode are possible over a work week, assuming the same mode is used for both trips in one day. Even more combinations exist if the time duration is longer or where it is practical to use different modes for each direction of a round trip such as bus one way and taxicab the other.

The potential to combine modes extends to situations where the automobile is the only practical form of transporation. Since modes are defined by their abstract characteristics, an auto trip along a toll road that provides a fast journey is a different mode from the same auto trip along free but slower surface streets. Motorists desiring to mix modes might select the toll road for some trips and surface streets for others. Greater modal mixing would likely occur if user charges were to be imposed along heavily traveled highways to promote economy in use [7]. Faced with the choice of a faster-costlier highway trip or a slower-cheaper trip along surface streets many motorists would choose to combine modes.

The opportunity to mix modes in varying proportions is thus most applicable to commuting where many trips are taken over an extended

period of time. Here the line AB becomes an isoquant in the traditional sense of representing a schedule of opportunities available to the producer of a trip. For isoquant AB to be a straight line requires that there be no fixed costs or associated cost or time advantage obtained from modal specialization that would yield economies of scale. Factors which lead to economies of scale include parking stickers, quantity discounts for commutation tickets, and experience in commuting (e.g., knowledge of schedules, road conditions, etc.). Where economies of scale prevail, the isoquant would be concave to the origin or scalloped as continuous line AB in Figure 3. This isoquant position is less preferred to the one arising from the linear combination of the modes (the dashed line AB).

In this context, it is interesting to reconsider mode D where $MC_{AD} < MC_{DB}$. In the Gronau analysis, this mode could not be selected because of the assumption of a constant value of time. Yet one need not rule out mode D if linear combination of modes A and B are impossible. If, however, it is found that a traveler selects mode D over either A or B or a combination of the two, this would clearly indicate that there must be economies of scale in travel.

While this section analyzes the production of modal mixing, the next section provides a rationale for modal mixing. It does this by integrating the Gronau model with the Moses and Williamson model. Modal mixing will be shown to be capable of providing the optimal choice even where economies of scale exist.

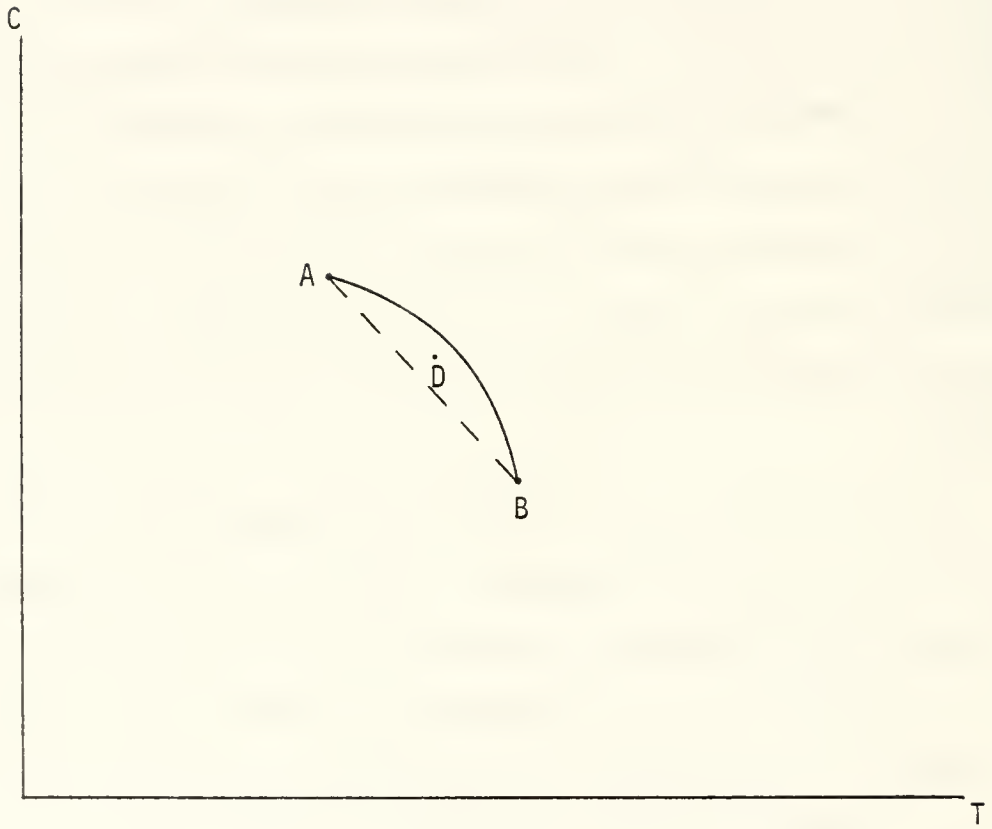

Figure 3

The Moses and Williamson Model

The Moses and Williams (M&W) study preceded Gronau's work by seven years. Nevertheless, the M&W article is far more general, providing sounder insights into the modal choice process, and suggesting the means for analyzing the benefits from transport improvements.

Figure 4 can be viewed as a synthesis of the Gronau and M&W approaches. The lower section of the Figure is an inverted Gronau diagram where the vertical axis extending downward measures commuting cost and the horizontal axis extending to the left measures commuting time. Points A and B represent the cost and time characteristics of the available modes. Isoquant AB represents achievable linear combinations of the two modes. An individual selecting the faster-costlier mode, A, would spend KL time commuting and ML in money cost.

The upper section of Figure 4 is developed in M&W space. Here the vertical axis represents income (net of commuting costs). The horizontal axis measures leisure time (time not spent commuting or working). The combinations of income and leisure available to an individual are affected by labor market constraints. M&W consider two possibilities. Either the individual has the freedom to work flexible hours at a constant wage rate or must conform to a standard work day. For the individual who works flexible hours at a given wage rate, income-leisure opportunities associated with taking mode A are represented by line AE. The negative slope of AE is the constant wage rate.[4] The situation changes when a fixed work day constraint, JK, is imposed. Then only opportunity point A on AE is attainable, and the individual spends KL time traveling, JK working, OJ in leisure, and has income net of commuting costs of OH.

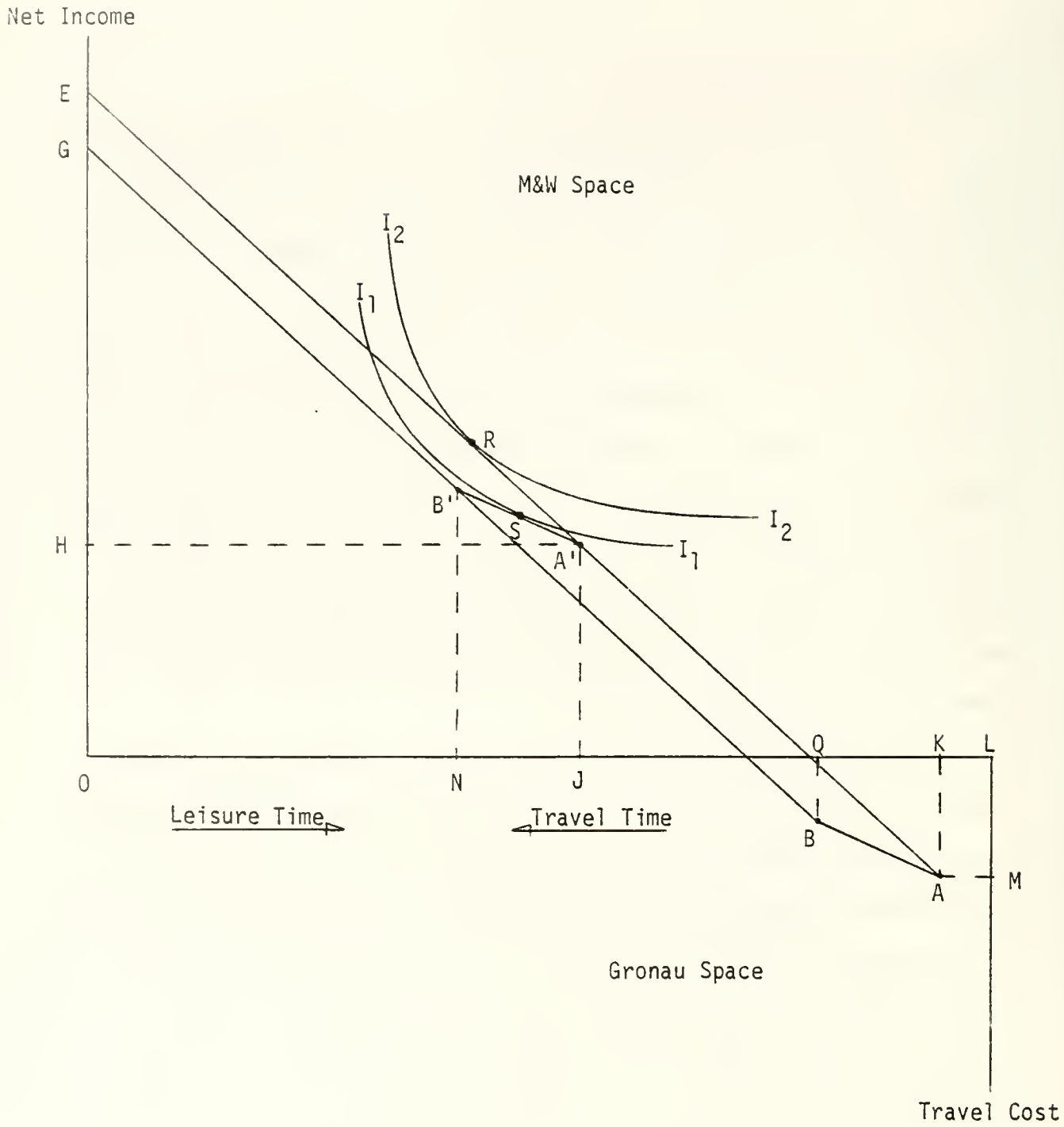
Net Income
E
G
M&W Space
I_2
I_1
R
B'
S
A'
I_2
I_1
H
O
N
J
Q
K
L
Leisure Time
Travel Time
B
A
M
Gronau Space
Travel Cost

Figure 4

Similarly, BG, parallel to AD, is the opportunity line associated with mode B in the flexible hours case and B' is the opportunity point for mode B given the same restriction of work time, NQ = JK. Finally, line segment A'B' in M&W space corresponds to isoquant AB in Gronau space, both with the same slope.

Individuals are assumed to derive satisfaction from both income and leisure. Their objective is to maximize their satisfaction from these quantities subject to an income-leisure opportunity constraint. On this basis they select their preferred mode. Their choice of mode may differ depending on whether they work flexible hours or are required to work a standard number of hours. With flexible hours, only the wage rate and MC_{AB} are necessary for establishing modal choices. As Figure 4 is constructed, $w > MC_{AB}$ causes AE to be to the northeast of BG. Since income-leisure combinations along AE can always be found that are superior to those along BG, mode A will clearly be the preferred mode. Thus for the individual depicted in Figure 4 with indifference curves I_1 and I_2, point R along opportunity line AE would yield the optimum mix of income and leisure. If $w < MC_{AB}$, BG would lie northeast of AE and mode B would be preferred. The flexible hours case resembles the Gronau analysis in that nothing need be known about consumer preferences to identify the preferred mode.[5] A further consequence of flexible hours is that linear combinations of modes are generally not relevant. This is because opportunity lines AE and BG would coincide only in the special case where $w = MC_{AB}$. Even in this case there would be no advantage to combining modes over specialization.

If an individual must work standard hours, knowledge of his wage rate together with the characteristics of available modes will not be sufficient to establish his modal choice. Information on preferences, how an individual values income relative to leisure, is also essential. We shall concentrate here on circumstances where an individual chooses to combine modes rather than use one exclusively. Modal mixing is more likely to occur when there are substantial differences in the abstract characteristics of available modes.

Figure 4 illustrates a situation where modal mixing at point S would be preferred by the individual whose indifference curves are I_1 and I_2 and who must work standard hours. It is assumed here that constant returns to scale permit linear combinations of modes A and B.

Figure 5 is developed assuming a scalloped isoquant in Gronau space which projects into a similarly shaped opportunity line connecting A' and B' in M&W space. Maintaining the fixed hour assumption, Figure 5 shows that modal mixing is not limited to situations where constant returns to scale apply. Line A'TB' represents opportunities available to the commuter. With indifference curves I_1' and I_2', the commuter would prefer position T which is achieved by combining modes A and B. Since scalloped isoquants involve a lower income-leisure position than linear combinations, mixing is less frequent. Indeed, the significance of scalloped isoquants may lie in explaining the infrequency of mixing.

From this analysis, more can be understood about the competitive position of mode D in Gronau space (see Figures 2 & 3). Recall that this mode could never be selected in the Gronau analysis, because together with proximate modes A and B, it formed an isoquant that was concave to

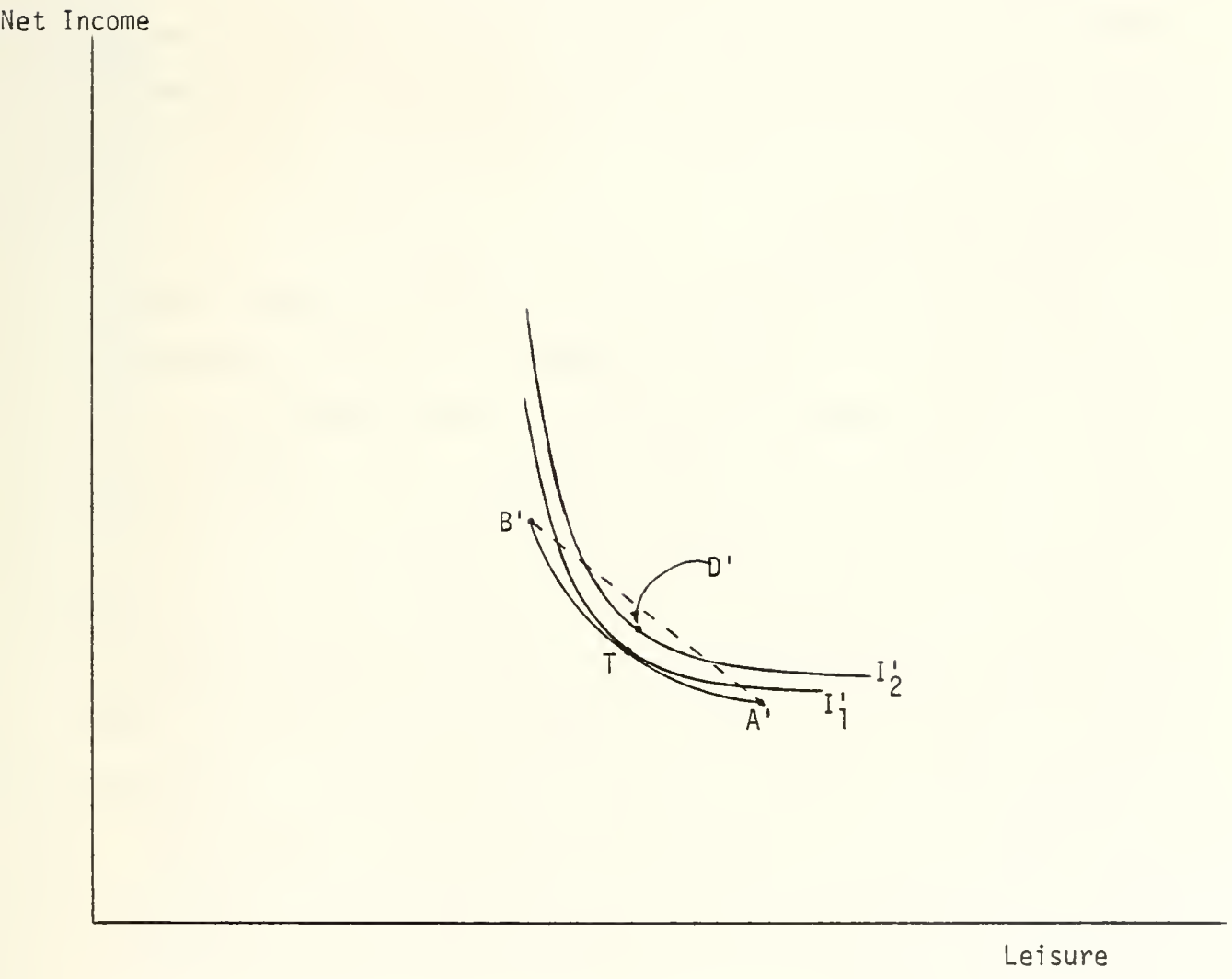

Figure 5

to the origin. Under the standard work hours condition, opportunity point D' associated with mode D may be the preferred income-leisure combination. This is the case in Figure 5 where the indifference curve passing through D' is higher than those passing through A' and B' (not shown). Thus mode D is preferred.

Part Time and Full Time Work

This section and the following section utilize an assumption about labor market opportunities which falls between the extreme assumptions of Gronau and M&W. Gronau claimed that his approach avoided utility analysis. As we have seen, the only labor market characteristics which make utility irrelevant for modal choice is flexible hours with a constant wage rate. M&W explicitly consider this case as well as the opposite extreme, completely inflexible work hours. The intermediate case considered here assumes flexible work hours at a part-time wage rate and completely inflexible hours at a higher full-time wage rate. The assumption of flexible hours at a part-time wage rate does not require that there be a single employer who would offer flexible hours. It only requires that an individual with one or more part-time jobs have only one commute of any substance.

Consider the discontinuous opportunity curve in Figure 6. Beginning with the cost and time of commuting indicated by point A, opportunities for less than full-time employment extend to point A'. The negative slope of AA' is the part-time wage rate. Point A' can be achieved by working full time at the part-time wage rate, whereas point A" can be achieved by working full time at the full-time wage rate. Opportunities

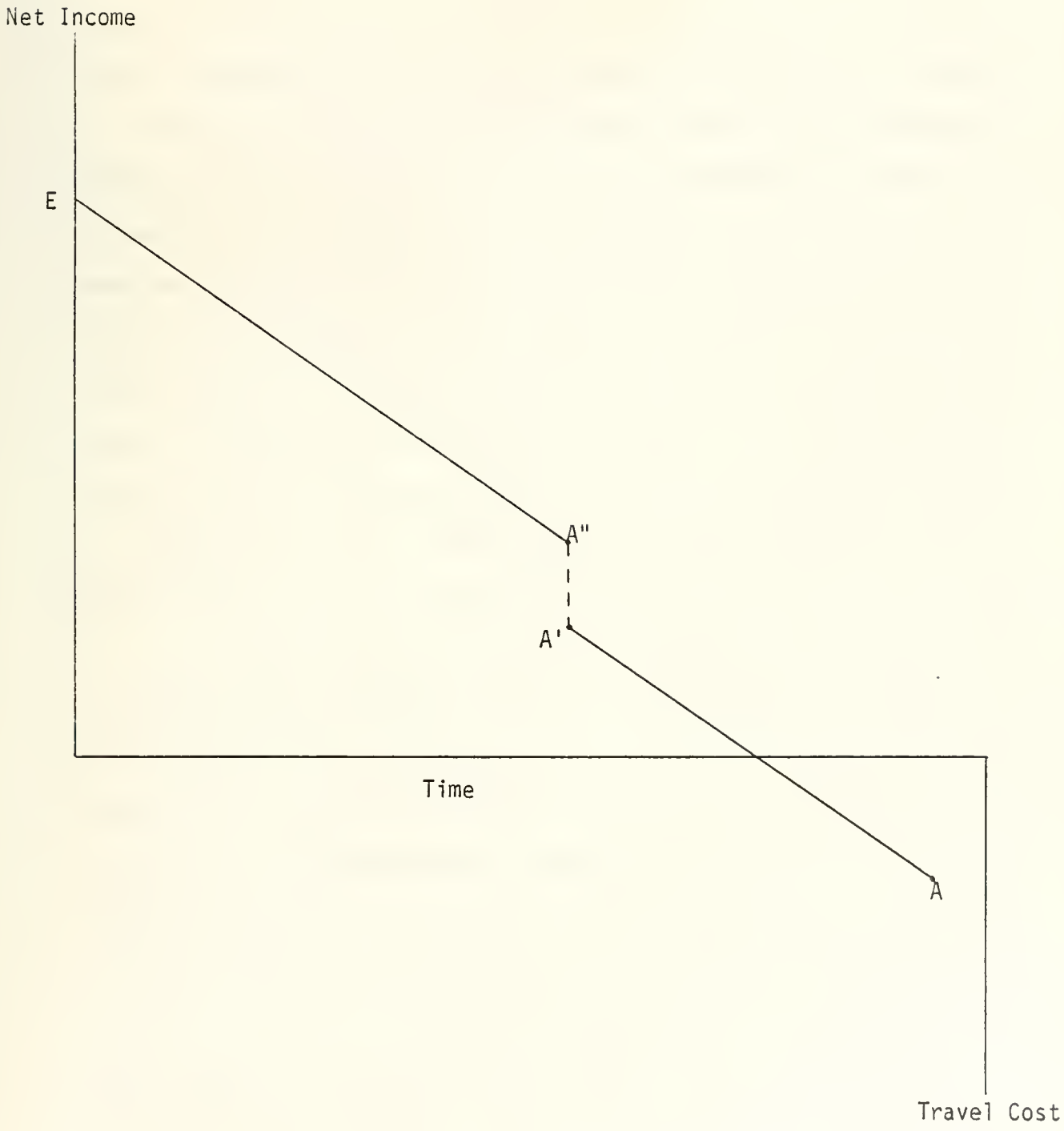

Figure 6

from A" to E are obtained by working full time and moonlighting at part-time jobs. So the negative slope of A"E is the part-time wage rate.

Figure 7 illustrates the opportunities available to an individual having a choice of two relevant modes. In particular, Figure 7 shows a situation in which the marginal cost of time exceeds the part-time wage rate. In this situation, a part-time worker or moonlighter would take mode B, the slower-cheaper mode. This is because the opportunity line associated with mode B is above the line associated with mode A in the range of part-time work. There is a minor exception to the rule that the part-time worker takes the slower-cheaper mode. If the scallop dips below the line A"E just to the northwest of A", it would be possible for a moonlighter to take mode A, the faster costlier mode.

A full-time worker might take either mode or mix modes depending on preferences. There is also a minor exception to this rule. Consider the net cost saving from taking the slower-cheaper mode to be the direct saving in cost minus the extra time in commuting valued at the part-time wage rate. If the premium for working full time (i.e., the size of the discontinuity) is less than the net cost saving, a full-time worker will never specialize in the faster-costlier mode.

Modal choice is more clearcut if the marginal cost of time is less than the part-time wage rate (not shown). Regardless of full-time or part-time status, only the faster costlier mode will be selected. Information on preferences is not required to determine modal choice.

The Subsidy Issue

The oft-quoted diversion prices from the M&W study assume flexible hours at the individuals' wage rate. In the event that hours are completely

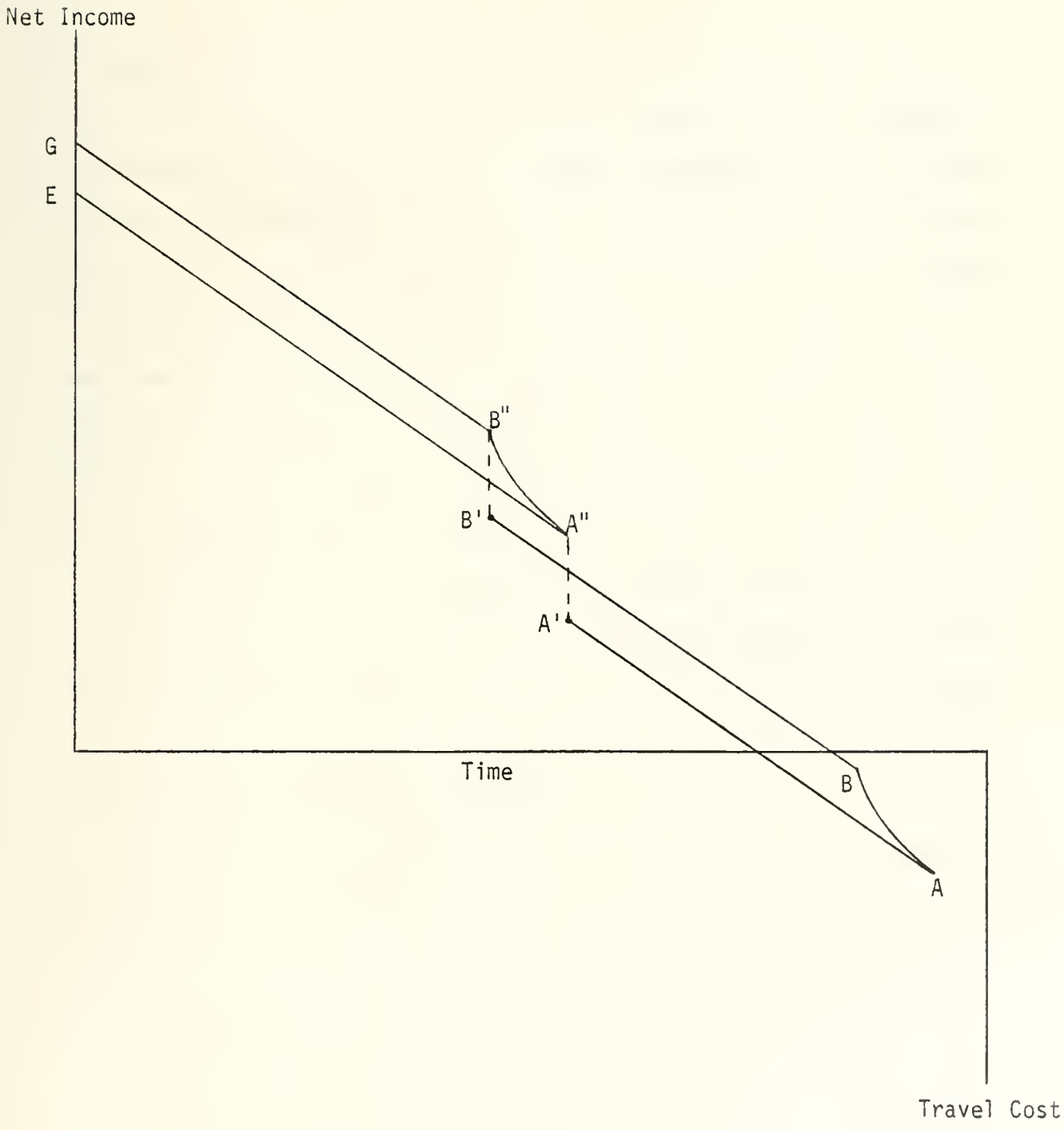

Figure 7

inflexible, M&W reveal the direction of bias in their diversion price estimates. However, we have no way of knowing the extent of bias. In this section, the intermediate case of flexible hours at a part-time wage rate and inflexible hours at a full-time wage is used to provide a range within which the diversion price must fall.

Our focus is on the interesting case of a full-time worker before and after a transport improvement. The transport improvement under consideration consists only of a reduction in time. The same two criteria used by M&W, the income supplement and the income levey, will be used to define the range of the diversion price. The income supplement is the subsidy necessary to make the individual just as well off as if he received the transport improvement. The income levy is the tax on the transport improvement that would leave the individual no better off than before the improvement.

Figure 8 illustrates the individual's opportunities before and after the transport improvement. The income supplement can be thought of as the necessary upward shift in the "before" opportunity line to reach an indifference curve, like I_1 or I_2, which goes through point A' but does not otherwise touch the "after" opportunity line. If the indifference curve is similar to I_1, very steep as it passes through A' and falling infinitesimally close to the "after" line in the part-time region, the upward shift in the "before" line is

$$z_p = (T_B - T_A)w_p$$

where z_p = the minimum income supplement, and

w_p = the part-time wage rate.

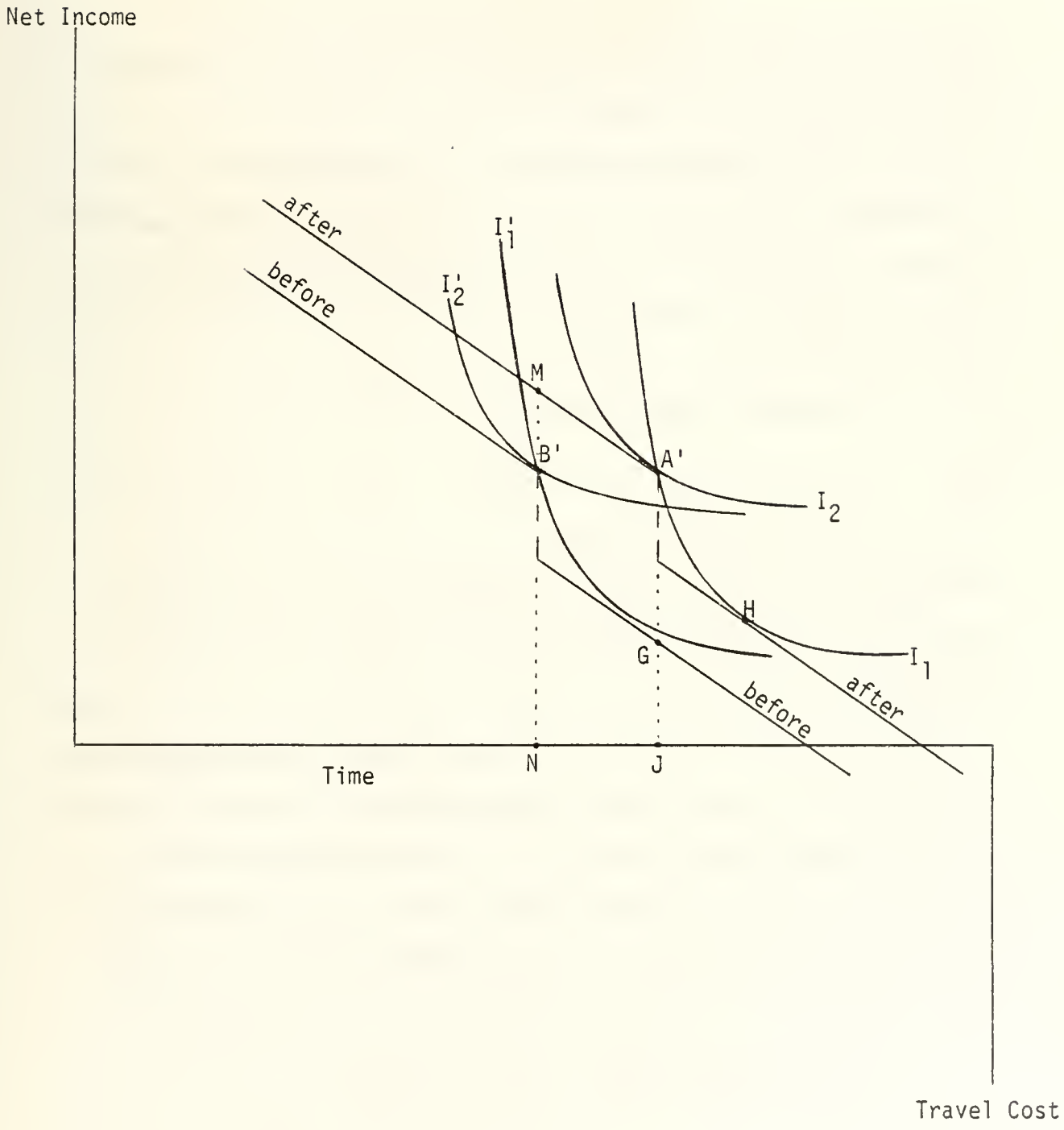
Net Income
after
before
I'_1
I'_2
M
B'
A'
I_2
H
G
I_1
after
before
Time
N
J
Travel Cost

Figure 8

A recipient of the minimum income supplement would work part-time and end up at income-leisure position H.

For the other extreme, suppose that the indifference curve, like I_2 in Figure 8, has a slope of $-w_p$ at A'. In this case, the income supplement must be equal to z_p plus the length of the discontinuity in an opportunity line. That is,

$$\text{the maximum income supplement} = z_p + (w_f - w_p)h_f$$

where w_f = the full-time wage rate, and

h_f = full-time work hours.

A recipient of the maximium income supplement would work part-time to receive JG which together with the income supplement would give him a final income of JA'.

Turning to the income levy criterion, we need to know the amount of the downward shift in the "after" curve needed to just allow the individual to reach the indifference curve, like I_1' or I_2', which passes through B' but does not otherwise touch the "before" line. If this indifference curve, I_1', only barely falls above the "before" line in the part-time region to the left of point G, the tax would have to be as much as

$$\text{the maximum income levy} = z_p + (w_f - w_p)h_f.$$

An individual paying the maximum income levy would work full-time or moonlight.

If, on the other hand, the difference curve has a slope of $-w_p$ at B', the downward shift in the "after" line need only be

$$\text{minimum income levy} = z_p$$

Any less of a shift would allow the individual to reach a higher indifference curve. An individual paying the minimum income levy would work overtime, receive income of NM, and after-levy income of NB'. Thus the range of diversion prices is the same for the income levy criterion as it is for the income supplement criterion. Note that if $w_p = w_f$, the diversion price is the same as in the M&W flexible hours case. This result shows that the individual's diversion price can be found within a rather narrow range if full-time and part-time wage rates are known.

Toward an Empirical Model

The theoretical structure developed in this paper can be used to formulate econometric models of travel demand. As an illustration of this capability, we consider the econometric treatment of competing modes. Defects of existing approaches are examined and some remedies are suggested based on the theory.

The Quandt and Baumol model estimated the demand for travel by a mode k along a given route as a function of the best characteristics of the modes serving the given route and the characteristics of the mode k relative to the best characteristics. The model suffers from a number of deficiencies [3, 6]. In particular, the model is deficient in capturing the impact of competing modes. Travel demand for mode k is not affected by changes in the characteristics of a competing mode unless those changes establish a new value for some best characteristics.

Young has attempted to remedy this deficiency by incorporating two new variables representing characteristics of proximate modes [8]. The proximate modes to mode k are the modes that are the next more expensive and faster and the next cheaper and slower. If T_{k-1} is the travel time

of the slower proximate mode and C_{k+1} is the travel cost of the more expensive proximate mode, Young's new relative performance variables are T_k/T_{k-1} and C_k/C_{k+1}. These variables can be added to the original Quandt and Baumol equation.

These new variables give some indication of the impact proximate modes have on mode k. Unfortunately, their usefulness is limited to changes in the inferior characteristics of the proximate mode. Where the superior characteristic undergoes change, there is no impact on mode k according to Young's model. That is, if the faster proximate mode becomes even faster, though not the absolute fastest, or the cheaper proximate mode becomes even cheaper, though not the absolute cheapest, these improvements will not reduce the demand for k. This problem cannot be corrected by introducing new relative performance variables based on the superior characteristic without risking pure multicollinearity. Thus, while the Young analysis suggests the importance of examining competing or proximate modes, it does not fully remove the deficiency in the Quandt and Baumol formulation.

The theory of modal choice suggests improvements in capturing the impact of competing modes on the demand for a particular mode. With two relevant modes, A and B, in Gronau space as shown in Figure 9, assume a hitherto unknown mode D is introduced. Suppose D is on the line segment D_1D_5. We would like to construct a travel demand function with the following desirable properties:

(a) If D is at D_1, it will eliminate travel on modes A and B. If D is at D_5, travel on it will be eliminated by diversion to modes A and B.

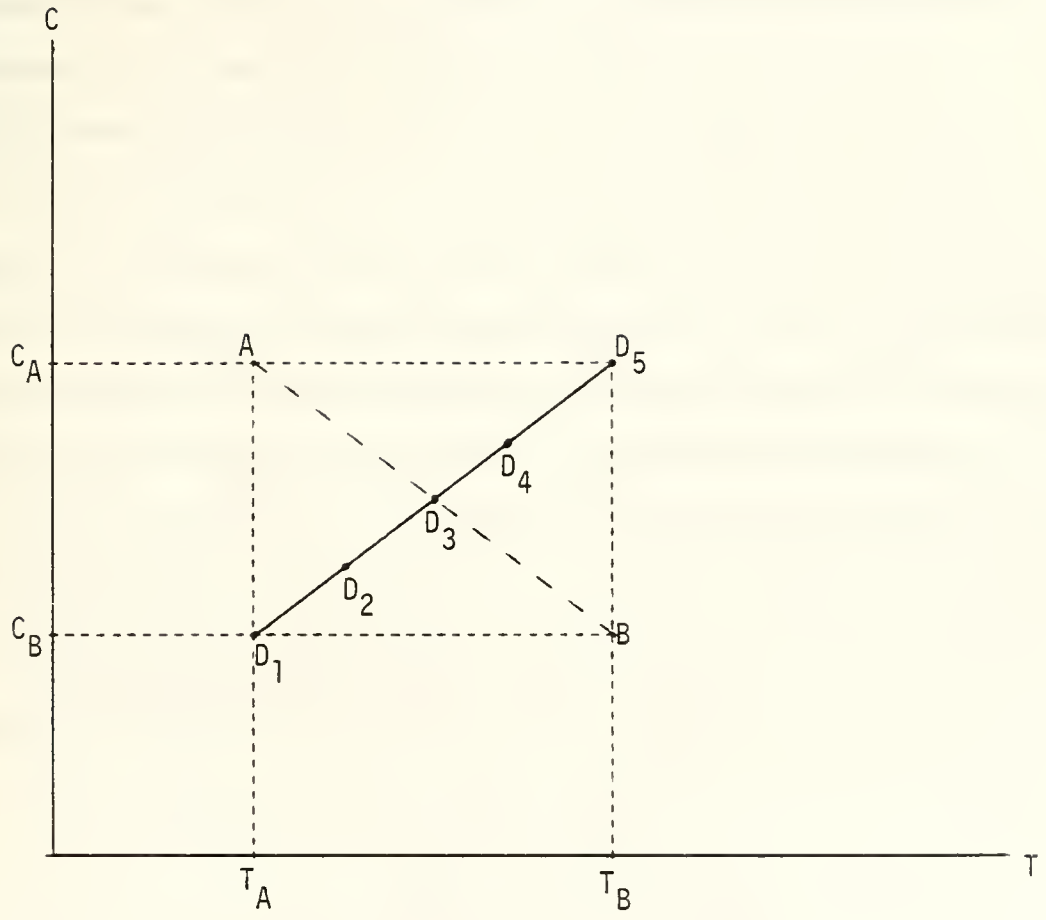

Figure 9

(b) As D moves northeast from D_1 (i.e., becomes more costly and time-consuming), the proportion of travelers taking competing modes A and B increases.

(c) If linear combinations of modes are possible, mode D between D_3 and D_5 would never be selected. Alternatively, economies of scale suggest that mode D would still attract travel demand if it falls within some distance to the northeast of D_3.

The number of travelers mode D takes away from modes A and B depends on how extreme is the "convexity" to the origin of isoquant ADB. The extent of "convexity" varies from a maximum at D_1 to a minimum at D_5 (i.e., with negative convexity or concavity occurring between D_3 and D_5). Figure 10 shows that a measure of convexity for mode D may be found by forming the variable $R = (90° - \beta - \gamma)$ where β and γ represent the angle deflections from the maximum convexity positions to proximate modes A and B. Since $\beta = \cot^{-1} \frac{DE}{AE} = \cot^{-1} MC_{AD}$ and $\gamma = \tan^{-1} \frac{BF}{DF} = \tan^{-1} MC_{DB}$, the marginal costs of time can be incorporated by rewriting R as

$$R = 90° - \cot^{-1} MC_{AD} - \tan^{-1} MC_{DB}.$$

At maximum convexity where $\beta = \gamma = 0$, $MC_{AD} = \infty$ and $MC_{DB} = 0$, the commuter always selects mode D since the marginal rate of substitution of income for lesiure would always be between MC_{BD} and MC_{AD}. R would then take on its maximum value of 90°. With zero convexity where $\beta + \gamma = 90°$ and $MC_{AD} = MC_{DB}$, R would be 0°. In this instance, there is no advantage to the commuter of selecting mode D under the restrictive assumption of a constant unit value of time. Under less restrictive assumptions, however, D may be preferred. If ADB is concave to the origin

(i.e., mode D_4 in Figure 10), then $\beta + \gamma > 90°$, and R is negative. For it to be possible for mode D to be selected where R is negative requires economies of scale in modal mixing as well as diminishing marginal rates of substitution of income for leisure. In summary, the competitive position of mode D declines as R becomes smaller.

The drawback in using R as an index of the competitiveness of a mode is that R is sensitive to the untis in which cost and time are measured. It is therefore necessary to measure the angles of displacement in standardized units. One approach, in the spirit of Quandt and Baumol, would be to develop cost-time characteristics for each mode relative to the best cost (C_b) and best time (T_b) characteristics. Thus, if we define relative cost and time characteristics for mode k as $C_k^* = C_k/C_b$ and $T_k^* = T_k/T_b$, then

$$MC^*_{AB} = \frac{C^*_A - C^*_B}{T^*_B - T^*_A} = \frac{MC_{AB}}{(C_b/T_b)}, \quad \text{and}$$

$$R^* = 90° - \cot^{-1} MC^*_{AD} - \tan^{-1} MC^*_{DB}$$

$$= 90° - \cot^{-1} \frac{MC_{AD}}{(C_b/T_b)} - \tan^{-1} \frac{MC_{DB}}{(C_b/T_b)}$$

The standardization of the marginal cost of time through diversion by (C_b/T_b) represents just one approach. In lieu of (C_b/T_b), suitable divisers would be selected on the basis of how closely they approximate the unobservable marginal value of time for the median traveler. This hypothesis can be most easily understood by assuming that there are only two modes, A and B. If the marginal value of time for the median traveler

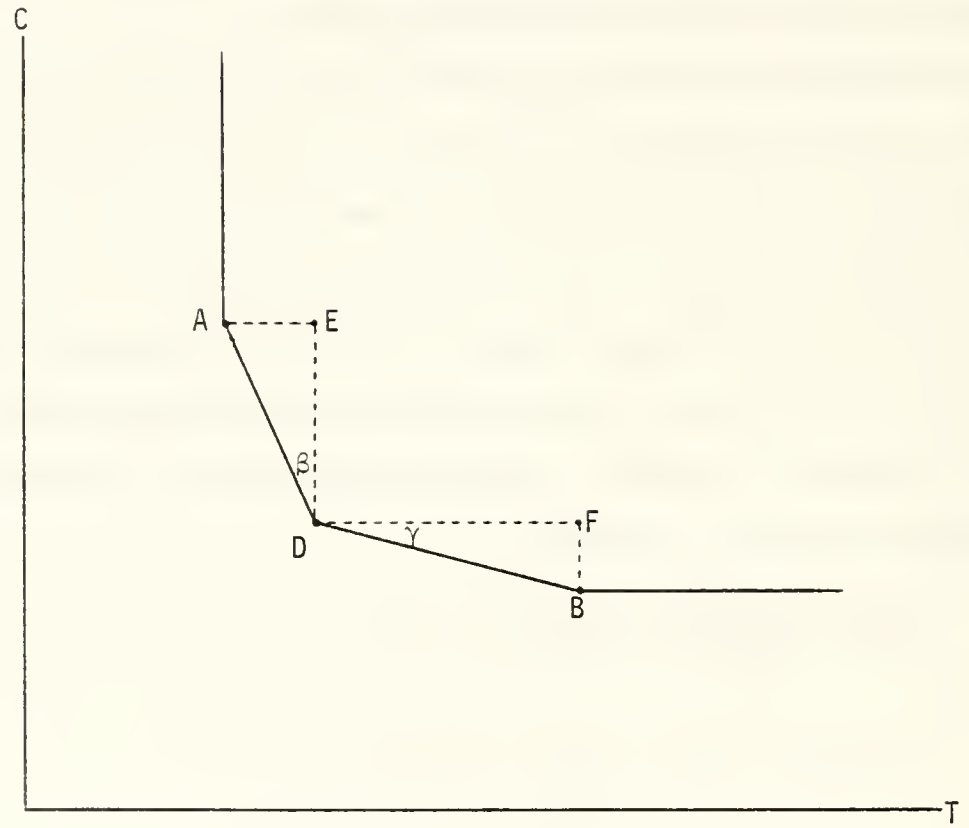

Figure 10

equals MC_{AB}, we would expect half the commuters to take mode A and half to take mode B. With the diviser equal to the marginal value of time, $MC^*_{AB} = 1$, and therefore $R^* = 45°$ for both mode A and mode B. Giving empirical life to this concept, one might use the median marginal cost of time for the divisor.

Conclusion

Theoretically, the choice of mode for the work trip is determined by the abstract characteristics of the modes, the technology with which modes are combined, labor market opportunities, and preferences. Institutional constraints on labor markets have important effects. For example, the commuter who must conform to a standard work day or who receives higher wage rates from working full-time than part-time may optimally choose to mix modes over time. However, the attractiveness of modal mixing is diminished when economies of scale exist in taking certain modes. With flexible hours at a part-time wage rate and inflexible hours at a higher full-time wage rate, upper and lower bounds can be established for valuing a transport improvement. Finally, the theory of modal choice suggests structural characteristics for empirical models.

FOOTNOTES

[1]Consider mode D such that $MC_{AD} < MC_{DB}$. Whatever the traveler's unit value of time, V, mode D will not be chosen. If $V > MC_{AD}$, mode A will be chosen over D, and if $V < MC_{DB}$, mode B will be chosen over D. Since $MC_{AD} < MC_{DB}$, there is no value of V consistent with the choice of mode D.

[2]The limiting case for a relevant mode would be one on the line AB. In that case, only if $V = MC_{AB}$ could this mode share some travel demand with modes A and B.

[3]Linear combinations have been used to identify the benefits of mixing trips. See [1].

[4]Travelers are assumed to view work and travel time as equally disagreeable so that time added to leisure can be considered a single characteristic regardless of whether the time is taken from work time or from travel time.

[5]Modal choice with flexible hours yields identical results to the Gronau analysis when the unit value of time (V) is defined as the wage rate. Mode A will always be selected when $V > MC_{AB}$ and mode B when $V < MC_{AB}$. This is because with flexible hours the commuter will always re-negotiate his work day to ensure the equality of his wage rate with his marginal value of time, his marginal rate of substitution of income for leisure.

REFERENCES

[1] W. B. Allen, "An Economic Derivation of the 'Gravity Law' of Spatial Interaction: A Comment on the Reply." Journal of Regional Science, 12 (1972), pp. 119-126.

[2] R. Gronau, "The Effect of Traveling Time on the Demand for Passenger Transportation." Journal of Political Economy, 78 (1970), pp. 377-394.

[3] R. Gronau and R. E. Alcaly, "The Demand for Abstract Transport Modes: Some Misgivings." Journal of Regional Science, 9 (1969), pp. 153-157.

[4] L. N. Moses and H. F. Williamson, Jr., "Value of Time, Choice of Mode, and the Subsidy Issue in Urban Transportation." Journal of Political Economy, 71 (1963), pp. 247-264.

[5] R. E. Quandt and W. J. Baumol, "The Demand for Abstract Transport Modes: Theory and Measurement." Journal of Regional Science, 6 (1966), pp. 13-26.

[6] R. E. Quandt and W. J. Baumol, "The Demand for Abstract Transport Modes: Some Hopes." Journal of Regional Science, 9 (1969), pp. 159-162.

[7] W. S. Vickrey, "Pricing in Urban and Suburban Transport." American Economic Review, 53 (1963), pp. 452-465.

[8] K. H. Young, "The Abstract Mode Travel Demand Models: Estimation and Forecasting." in Studies in Travel Demand, Vol. IV (1968), pp. 1-36, Mathematica.

BOUND BY
HV
3-94

UNIVERSITY OF ILLINOIS-URBANA
3 0112 060296321